Contribution to the Lithology of Pennsylvania.

On the Physical and Chemical Characteristics of a Trap occurring at Williamson's Point. By Persifor Frazer, Jr. (1 colored plate.)

(Read before the American Philosophical Society, Dec. 20th, 1878.)

A thin vein of trap intersects the chloritic rocks at Williamson's Point, on the Susquehanna River in Lancaster Co. Pennsylvania, and near the Maryland line.

This trap dyke which cuts through the hard quartzose and chloritic rock at Williamson's Point is peculiar in its isolation from known rocks of igneous origin ; in the manner in which it is foliated transversely to its contact planes ; and in its disappearing on its under side in a feather edge. Its upper continuation is now obscure from the denudation of the rocks which it intersects, but as far as it can be followed it widens in an upward direction, and the uneven facade of rock against which it appears gives it the semblance of being dislocated in places, but this is a deception of the judgment.

The rocks are here twisted in a most extraordinary manner, and this twisting is more remarkable just south of the position of the dyke. A very fine specimen of a portion of this vein, with both walls distinct and attached on one side to the rock which it intersected, is No. 1760 in the collection of the Geological Survey.

An examination of this specimen will reveal the fact that the fissure has not been exactly along planes of lamination, but truncates the tops of several small waves into which the strata have been forced.

A specimen of this trap was obtained and reduced to a thin section, of which a representation as seen under a power of 400 diameters and in polarized light has been very faithfully made by Mr. Faber.

It was not found expedient in this drawing to imitate exactly all the details in any one field of view, but the more characteristic exponents of the minute crystals were brought together from all parts of the slide and substituted for those less perfectly formed; due regard being had always to the proportions in which the several constituents of the mass manifested themselves.

In the centre of the field is a large double, or multiple, columnar crystal of labradorite to the bottom, and to the middle of which other smaller crystals are attached—whether accidentally in contact or an off shoot in the former case is not certain.

In the upper left hand portion of the field a curious instance of the splitting of labradorite may be observed. It was at first thought that the apparent divergent curvature of the two branches of this crystal might be an optical delusion, and that in reality two independent individuals were thus accidentally in contact at one extremity. Under higher powers than that here given, however, it proved to be an actual ramification of the mass from one common stock like the growth of twigs from the same branch.

The other labradorite crystals will be easily distinguished by the eye,

HUNDREDTHS OF ONE MILLIMETER.

Thin section of Trap from Williamson's Point,
Lancaster Co. Pa.
Magnified 400 Diameters.

and as usual are characterized by their tendency to separate into two or more parts, colored respectively light brown and pale blue.

The four masses of pyroxene are equally distinguishable by the peculiar net work of clefts which cover surfaces, which in polarized light present usually one of the tints here distributed among them. It is often the case when a thin slide has been carefully and evenly made, that at a certain position of the analyzer all the labradorite divides itself into its two characteristic colors depending upon the positions of the optical axes of a pair or a series of the twins. With pyroxene it is different. The fragments, in these traps at least, rarely show definite crystalline form, and in any given position of the analyzer there may be found specimens exhibiting any of the indefinitely large number of gradations in color between bright green and dark violet which accompany the rotation of the analyzer through the angle which separates the projection of their optical axes.

Only a single hexagonal section is given in the picture, but these figures are distributed, though not profusely, throughout the mass. This is probably a minute column of Apatite, and the low percentage of Phosphoric Oxide in the accompanying analysis sufficiently explains why these forms are comparatively rare.

A number of these hexagonal forms having been examined, it was found that when most symmetrical they exercised no influence on polarized light and were, therefore, sections perpendicular to the optical axis of an hexagonal crystal since the basal plane assumed this form.

But where the hexagons were distorted, or in the frequent cases where they were covered by a film of vitreous pyroxene or labradorite, the extinctions were more or less irregular.

One of the quasi-hexagons measured 0.048 mm. between the parallel edges.

The comparatively large rhombic figure is in all probability a section of calcite parallel to one of the planes of the rhombohedron. Several of these figures were measured and examined. One of them was 0.11 millimeter in the longer axis. The angles as measured were 81° 03′ and 98° 36′ respectively. This crystal showed four positions of maximum transparency, and four positions of extinction alternating with each other at distances of 45°* Another and the largest similar section which was measured showed a longer axis equaled to 0.25 mm.

An examination under the improved Füss's microscope with a magnifying power of 275 diameters gave :

Acute angle.................................. 80° 30′ ⎫
                                                      ⎬ 180°
Obtuse angle............................... 99° 30′ ⎭

In this case there was no general extinction of light during one revolution with or without the quartz prism.

*The microgoniometer having been set at zero when the Nicols were crossed, the succeeding positions of extinction were very nearly 0°, 90′ 180″, and 270°

The modifications of light at a few points seemed to be caused by impurities.

A small rhomb examined in the Füss instrument, under a magnifying power of 275 diameters gave :

Acute angle (imperfect).................... $73° 30'$ } $172°$
Obtuse angle   "   .... $98° 30'$ }

A profusion of small black specks distinguished the face of this crystal which was apparently therefore not homogeneous. It showed four extinctions.

A third rhombus at 275 diameters showed :

Acute angle........................ .... $72°$ } $173°$
Obtuse angle................................. $101°$ }

Neither of the above angles was perfect.

This crystal also showed four extinctions.

The ground mass is composed of minute objects, often stellate in structure, among which are probably small columnar masses of Rutile, as the titanic oxide in the analysis suggests. They are exceedingly small and, except here and there, do not indicate any definite order or arrangement.

This ground mass is not certainly determined. The tufts are sometimes flat and *frayed* at the ends like a piece of worn cloth. They polarize feebly within different shades of brown.

The following is an analysis of this trap by Dr. Genth.

Silica (SiO_2)... 50.79
Titanic Oxide (TiO_2)................................ 0.70
Phosphoric Oxide (P_2O_5)............................ 0.15
Alumina (Al_2O_3)..................................... 14.19
Iron Sesqui-oxide (Fe_2O_3).......................... 3.84
Ferrous Oxide (FeO)................................... 7.44
Manganous Oxide (MnO)............................. 0.48
Lime (CaO)... 9.75
Magnesia (MgO).................................... 7.88
Potash (K_2O)....................................... 0.95
Soda (Na_2O).. 1.89
Ignition... 1.95

Total.. 100.01

Herewith are presented, side by side, average analyses of Labradorite and of Pyroxene both calculated from the data given in the last edition of Dana's System of Mineralogy (Fifth Edition, 1877). The former is based upon forty analyses of Labradorite and the latter on eighteen analyses of Pyroxene from eruptive rocks.

	Labradorite average of 40 analyses.	Pyroxene average of 18 analyses.
Silica (SiO₂)	53.00	49.35
Alumina (Al₂O₃)	27.96	5.79
Iron Sesqui-oxide (Fe₂O₃)......	1.33	—
Ferrous Oxide (Fe₂O)....	—	8.30
Magnesia (Mg₂O)	0.93	13.88
Lime (CaO)	10.88	20.86
Soda (Na₂O)	4.09	—
Potash (K₂O).................................	1.08	—
Manganous (MnO)	—	0.27
Water.....	0.84	0.19
	100.11	98.64

In the following table the percentage of each constituent in Dr. Genth's analysis of this trap is doubled, and the result compared with a column showing the sums of the percentages of the average Labradorite, and the average Pyroxene :

	Sum of La- bradorite & Pyroxene.	Double Per- centage of Dr. Genth's analysis.
Silica (SiO₂)	102.35	*102.43
Alumina (Al₂O₃).............................	33.75	28.38
Iron Sesqui-oxide (Fe₂O₃).	1.33	7.60
Ferrous Oxide (FeO)	8.30	14.88
Manganous Oxide (MnO).......................	0.27	0.90
Magnesia Oxide (MgO)	14.81	15.76
Lime (CaO)	31.74	19.50
Soda (Na₂O)	4.09	3.70
Potash (K₂O).......	1.08	1.90
Water (H₂O).	1.03	†3.90
	198.75	199.17

It will be seen that the two columns agree remarkably well in most particulars, which is the same as saying that the composition of the rock is very nearly what the chemical analysis of a mixture of one molecule of Labradorite and one molecule of Pyroxene would show.

In Report of Progress C, 1876,‡ a number of similar traps were discussed and analyses given ; amongst others of one from "West Rock," Connecticut, and one from Beeler's farm, York County.

The composition of the former, like the one here considered, agreed more nearly with a distribution of Labradorite and Pyroxene molecules in the proportion of one to one, while the "Beeler" trap corresponded more nearly with the mixture of two molecules of Labradorite with one of Pyroxene.

* 0.70 Ti O₂ and 0.15 p. c. P₂ O₅ included in SiO₂.
† Ignition.
‡ Second Geol. Survey of Penna.

In the present case tables of comparison were made on the basis of 2 L+P, and 3L+P,* but none agreed so closely as the two first made and presented above.

It should be mentioned that a slight error is due to the counting of all the titanic oxide and phosphoric oxide as part of the silicic oxide, neglecting at the same time to make the necessary allowance for the quantivalential and atom-weight differences, but the amount of these substances was so small that the error will be entirely inappreciable. And besides, even this small error will be avoided in the considerations presented below.

The same is true of the method here followed, which is simply to compare the ascertained percentages of the compounds instead of reducing the analysis to percentage weight of the elements and striking a balance between the electro-negative and the electro-positive elements. This latter method is much more exact but is too delicate and no better for the purpose than the rough and ready system here followed. A comparison of the same bodies given above in their percentage values would be as follows :

	P. c. composition. 1 L. + 1 P.	Analysis of trap.
Silica (SiO₂)	51.50	†51.64
Alumina (Al₂O₃)	16.95	14.19
Iron Sesqui-oxide (Fe₂O₃).......................	0.67	3.84
Ferrous Oxide (FeO)	4.17	7.44
Manganous Oxide (MnO).........................	0.13	0.48
Magnesia (MgO)................................	7.45	7.88
Lime (CaO).....................................	16.00	9.75
Soda (Na₂O)....................................	2.55	1.89
Potash (K₂O)...................................	0.55	0.95
Water (H₂O)....................................	0.52	‡1.95

It will be observed that the theoretical composition requires more Alumina and Lime than are given in the analysis. The alkalies are about the same in both, for there is a little less soda and a little more potash in the rock, which contains also more iron as both sesqui-oxide and protoxide.

Manganese is too small to consider, as is also the slight difference in the per cent. of Magnesia.

The analysis thus considered tells us that the actual composition of the rock, though near 1 : 1 of labradorite and pyroxene, is not quite that, being slightly deficient in alumina and lime (Labradorite), while the excess of the two oxides of iron remind us that we are not to forget one of the most generally distributed constituents of these traps—e. g. magnetite ; though really under the microscope this mineral is not at all prominent.

The study of the microscopic section having led to the suspicion of cal-

* L stands for one molecule of Labradorite. P stands for one molecule of Pyroxene.

† Including TiO₂ and P₂O₅.

‡ Ignition.

cite in the rock, a great number of specimens were tested for effervescence, and all showed it in a prominent degree. As the above analysis of Dr. Genth gave no carbonic oxide, on inquiry, he writes : "The rock is full of cracks and these are lined with a minute quantity of calcite. The portion of which I sent you the analysis was as nearly as possible selected from that which did not show this coating. * * * Still some of the 'Ignition ' may be CO_2," &c., &c.

It is clear from the position of these calcite crystals that they cannot all be due to infiltrated solutions of calcium carbonate through cracks in the rock, because the individual crystals are isolated from each other.

Their occurrence is peculiar and will be the subject of future study.

Three separate determinations of ignition were 3.65, 3.40, and 3.88 (average 3.64).

Average determination of $CO_2 = 1,49$ p. c.

Annexed is the analysis, resolved into the ultimate constituents of the rock (including 1 p. c. out of the ignition for CO_2).

ANALYSIS OF WILLIAMSON'S POINT TRAP.

Acid

p. c.		Oxygen p. c.	
Si. . . . . .23.71 ⎫ C . . . . .0.27 ⎬ Ti. . . . . .0.43 ⎪ P. . . . . .0.07 ⎭	24.48	Oxygen . . . . .27.08 ⎫ " . . . . 0.73 ⎬ " . . . . 0.27 ⎪ " . . . . 0 08 ⎭	28.16

Basic.

Al. . . . . .7.55 ⎫ Fe^{iv} . . . . 2.69 ⎬	10.24	Oxygen . . . . 6.64 ⎫ " . . . . 1.15 ⎬	7.79
Fe^{ii} . . . . .5.79 ⎫ Mn . . . . .0.37 ⎪ Mg . . . . .4.68 ⎪ Ca. . . . . .6.97 ⎬ Na. . . . . .1.40 ⎪ K . . . . 0.79 ⎭	20.00	Oxygen . . . . 1.65 ⎫ " . . . . 0.11 ⎪ " . . . . 3.20 ⎪ " . . . . 2.78 ⎬ " . . . . 0.49 ⎪ " . . . . 0.16 ⎭	8.39
	54.72		44.34

Considering this collection of atoms as united into molecules in which the oxygen performs partly a linking and partly a saturating function, we may discover something as to the probable kinds of silicates contained.*

The chemical units into which this analysis is resolved below represent the amount of *bond satisfying* work which each atom performs, so that the total amount might with propriety be considered the quantity of *molecule constructing* work performed. It is calculated by considering the number of atoms of each element present, multiplied by the quantivalence of

* On this subject see Report C, 1876, pp. 115 to 124.